METHODS AND SYSTEMS FOR ROUTING MESSAGES IN A RADIO ACCESS NETWORK

AN APPLICATION FOR

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Description

METHODS AND SYSTEMS FOR ROUTING MESSAGES IN A RADIO ACCESS NETWORK

Technical Field

The present invention relates to methods and systems for routing messages in a radio access network. More particularly, the present invention relates to a gateway that routes and translates messages between a core network and a radio network controller that simplifies core network elements.

Background Art

A radio access network (RAN) is a collection of network elements that enables calls to occur between mobile subscribers. Such a network includes nodes that carry voice traffic, signaling traffic, and a combination of voice traffic and signaling traffic. Figure 1 illustrates a prior art radio access network used to provide wireless communication service to mobile subscribers. Such RAN network architectures include a number of functional components including transceiver stations **100**, radio network controllers (RNCs) **102**, and a core network **104**. Core network **104** includes asynchronous transfer mode (ATM) network elements, such as ATM switches, that carry voice and signaling traffic relating to communications to and from mobile subscribers. As such, these switches are required to implement a variety of different

communication protocol layers, including various ATM and SS7 protocol layers. Implementing multiple different protocol layers in the core network may be undesirable because it increases the complexity of core network elements, such as ATM switches.

Figure 2 illustrates exemplary communication protocol layers that are implemented on interconnection point Iu between core network **104** and a radio network controller **102**, as illustrated in Figure 1. In the illustrated example, three different types of messages are communicated between the core network and the RNC over the connection point Iu. One type of message is represented protocol stack **200**. Protocol stack **200** is used to carry radio access network application part (RANAP) messages between the core network and the RNC. RANAP messages are radio network signaling messages. The next layer in protocol stack **200** is the signaling connection control part (SCCP) layer. This layer performs SS7 functions, such as global title translation. The next layer is message transfer part layer 3 broadband (MTP3B), which carries large payloads (4091 bytes versus 272 bytes for normal MTP3) of SS7 traffic. The next three layers, the service specific coordination function network to network interface (SSCF-NNI) layer, the service specific connection oriented protocol (SSCOP) layer, and the ATM adaptation layer 5 (AAL5), are related to the ATM protocol. The AAL5 layer supports connection-oriented variable bit rate data services. The SSCOP layer provides TCP-like services, such as flow control, timeouts, and retransmissions for ATM networks. The purpose of the SSCF-NNI layer is to enhance the service of SSCOP to meet the needs of the NNI level 3 protocol. In addition, the SCCF at the NNI provides communication with layer

management for the proper operation of signaling links. Finally, the network layer, just above the physical layer is the ATM layer, which provides for the establishment of virtual circuits and transmission of ATM cells between endpoints.

Protocol stack **202** carries call setup messages for radio access networks. For example, Q.2630.1 messages are used for ATM bearer connection establishment and the binding of an ATM bearer connection or channel to a telephony connection. As used herein, Q.2630.1 refers to functionality described in International Telecommunication Union Telecommunication Standardization Sector (ITU-T) Recommendation Q.2630.1, September 29, 1999, the disclosure of which is incorporated herein by referenced in its entirety. The Q.2510.1 layer provides AAL type 2 signaling transport converter service for broadband MTP. As used herein, the Q.2510.1 layer refers to functions described in ITU-T Recommendation Q.2510.1, June 23, 1999, the disclosure of which is incorporated in herein in its entirety. The remaining layers in protocol stack **202** are ATM layers that perform the same or similar functions to the correspondingly-named layers of protocol stack **200**.

Protocol stack **204** carries user data, such as digitized voice, between the RNC and the core network. As such, protocol stack **204** includes a user part layer that contains the actual user data, an AAL2 layer, which supports connection-oriented services that do not require constant bit rates, such as variable bit rate video applications.

Providing the multiple protocol layers illustrated in Figure 2 in core network elements, such as ATM switches, increases the complexity and cost

of these elements. Accordingly, there exists a long-felt need for methods and systems for communicating between the core network and radio network controllers that reduces the complexity of core network elements.

Disclosure of the Invention

According to one aspect, the present invention includes methods and systems for communicating between a radio network controller and a core network that reduce the complexity of core network devices. The invention includes a gateway that translates between conventional core network protocols such as MTP3B, SSCF-NNI, SSCOP, AAL5, and ATM and a universal protocol, such as SS7 SCCP-User Adaptation Layer (SUA) over stream control transmission protocol/Internet protocol (SCTP/IP). The SS7 SCCP User Adaptation Layer is described in IETF internet draft <draft-loughney-sigtran-sua-00.txt, March, 2000, the disclosure of which is incorporated herein by reference in its entirety. The stream control transmission protocol is described in detail in RFC 2960, Stream Control Transmission Protocol, October 2000, the disclosure of which is incorporated herein by reference in its entirety. Providing a gateway that performs these translations reduces core network element complexity because core network elements can implement a single protocol stack for which hardware and software are readily available and inexpensive, such as SUA over SCTP/IP or TCP/IP, when communicating with radio network controllers.

As used herein, the phrase "core network" refers to the network used to carry signaling and bearer traffic to and from radio network subsystems (RNSs). Such a network has conventionally included only ATM and SS7

network elements. Because of the gateway of the present invention, such a network can include elements that communicate using a universal transport protocol, such as SCTP/IP or TCP/IP. In addition, because the gateway of the present invention translates between conventional core network protocols used by RNCs and a universal transport protocol, no modification to RNC nodes is required.

The term "radio network subsystem" refers to the collection of network elements that allow user equipment, such as mobile handsets, to access the universal mobile telecommunication system terrestrial radio access network (UTRAN). An RNS may include one or more radio network controllers (RNCs), which control the integrity and use of radio resources. An example of a commercially available radio network controller (RNC) is a switch manufactured by NEC Corporation that is based on the NEAX61 ATM switch. The UTRAN refers to the network that controls user access to the core network.

Definitions and examples of the terms used herein can be found in 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Overall Description (3G TS 25.401 version 3.1.0 Release 1999), the disclosure of which is incorporated herein by reference in its entirety.

Brief Description of the Drawings

A description of preferred embodiments of the invention will now proceed with reference to the accompanying drawings, of which:

Figure 1 is a block diagram of a conventional UTRAN architecture;

Figure 2 is a protocol layering diagram illustrating protocols conventionally used to communicate between the core network and a radio network controller;

Figure 3 is a block diagram of a radio access network including a radio access network gateway according to an embodiment of the present invention;

Figure 4 is a block diagram of an exemplary signaling gateway architecture for implementing a radio access network gateway according to an embodiment of the present invention;

Figure 5 is a block diagram of the internal structure of a RAN gateway according to an embodiment of the present invention;

Figure 6 is as block diagram of a radio access network illustrating exemplary messages processed and formulated by a RAN gateway according to an embodiment of the present invention;

Figure 7 is a protocol layering diagram illustrating exemplary functions performed by a RAN gateway in translating RANAP messages to and from a universal message format according to an embodiment of the present invention;

Figure 8 is a block diagram of a radio data communications module according to an embodiment of the present invention;

Figure 9 is a protocol layering diagram illustrating exemplary functions performed by a RAN gateway in translating bearer access control messages to and from a universal message format according to an embodiment of the present invention;

Figure 10 is a block diagram of a radio data communications module including a billing module according to an embodiment of the present invention; and

Figure 11 is a block diagram of a RAN gateway including a billing subsystem according to an embodiment of the present invention.

Detailed Description of the Invention

Figure 3 illustrates a radio access network (RAN) including a RAN gateway according to an embodiment of the present invention. In the illustrated embodiment, radio access network **300** includes a core network **302**, one or more radio network controllers **102**, and a plurality of node Bs **100**. Core network **302** includes network elements for communicating signaling and bearer traffic to and from RNCs **102**. Such network elements have conventionally been SS7 and ATM-based network elements. However, as will be explained in more detail below, RAN gateway **304** provides functionality that allows core network **302** to implement a universal protocol, such as SCTP/IP or TCP/IP. RNCs **102** control access to radio resources of core network **302**. Node Bs **100** are logical nodes responsible for radio transmission and reception in one or more cells to and from user equipment, such as mobile handsets. On the RNC side, each node B terminates the interface Iub with the RNC.

A proposed standard for the Iu interface between the core network and an RNC is found in 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu Interface: General Aspects and Principles, Release 1999, the disclosure of which is incorporated herein by

reference in its entirety. In this document, the interface used to carry signaling messages between the core network and the RNC is referred to as the control plane. There are circuit and packet switched interface proposed for the control plain. Both the circuit and packet switched interfaces rely on ATM as the underlying transport layer for carrying signaling messages to and from the core network.

RAN gateway (RANGW) **304** receives ATM-based RAN signaling messages that include an application part from a RAN network controller (RNC) node. RAN gateway **304** encapsulates the application part component of the RAN messages within an SS7 SCCP User Adaptation (SUA) or SS7 MTP3 User Adaptation (M3UA) wrapper. SS7 SCCP User Adaptation Layer is described in the above-referenced IETF Internet Draft. The SS7 MTP3 User Adaptation Layer is described in IETF Internet Draft <draft-ietf-sigtran-m3ua-04.txt>, March 2000, the disclosure of which is incorporated herein by reference in its entirety.

RAN gateway **304** also strips the lower level ATM-based protocol information from messages received from RNCs **306** and replaces this lower level protocol content with a universal protocol, such as SCTP/IP or TCP/IP. The RNC side of RAN gateway **304** may include a high speed ATM link module for communicating ATM-encapsulated messages to and from RNCs **102**. The core network side of RAN gateway **304** may include a RAN data communication module (rDCM) for communicating RANAP and other messages to and from core network **302** using SCTP/IP, TCP/IP, or other universal message format. The main function of RAN gateway **304** is to reduce the need for ATM, SSCF, SSCOP and MTP3 functionality in core

network **302**. Removing these layers from core network **302** into a single highly reliable point outside of core network **302** greatly simplifies core network elements. For example, rather than using ATM switches to communicate messages to and from RNCs **102**, core network **302** can include machines running IP-protocols, which are much less expensive than ATM switches.

Disclosed herein are several embodiments of the present invention, all of which include a network element that performs functions similar to that of a traditional telecommunications network packet routing switch, such as a signaling gateway (SG) routing node. Each of the embodiments described and discussed below, employs an internal architecture similar to that of high performance signal transfer point (STP) and SG products which are marketed by Tekelec of Calabasas, California as the Eagle® STP and IP⁷ Secure Gateway™, respectively. A block diagram that generally illustrates the base internal architecture of the IP⁷ Secure Gateway™ product is shown in Figure 4. A detailed description of the IP⁷ Secure Gateway™ may be found in Tekelec publication PN/909-0767-01, Rev B, August 1999, entitled *Feature Notice IP⁷ Secure Gateway™ Release 1.0*, the disclosure of which is incorporated herein by reference in its entirety. Similarly, a detailed description of the Eagle® STP may be found in the *Eagle® Feature Guide* PN/910-1225-01, Rev. B, January 1998, published by Tekelec, the disclosure of which is incorporated herein by reference in its entirety. The specific functional components of an IP⁷ Secure Gateway™ for transmitting and receiving transaction capabilities application part (TCAP) messages over an Internet protocol (IP) network are described in commonly-assigned, co-pending international publication number WO

00/35155, the disclosure of which is incorporated herein by reference in its entirety. Similarly, the functional components of an IP[7] Secure Gateway™ for transmitting and receiving ISDN user part (ISUP) messages over an Internet Protocol (IP) network are described in commonly-assigned, co-pending international publication number WO 00/35156, the disclosure of which is also incorporated herein by reference in its entirety. As described in the above referenced *Feature Notice IP[7] Secure Gateway*™ and as illustrated in Figure 4, an IP[7] Secure Gateway™ **400** includes the following subsystems: a maintenance and administration subsystem (MAS) **402**, a communication subsystem **404** and an application subsystem **406**. MAS subsystem **402** provides maintenance communications, initial program load, peripheral services, alarm processing and system disks. Communication subsystem **404** includes an interprocessor message transport (IMT) bus that is the main communication bus among all subsystems in IP[7] Secure Gateway™ **400**. This high-speed communications system includes two 125 Mbps counter-rotating serial buses.

Application subsystem **406** includes application cards that are capable of communicating with the other cards through the IMT buses. Numerous types of application cards can be incorporated into IP7 secure gateway **400**, including, but not limited to: an ATM-based high speed link interface module (HSL) **408** that provides SS7 links and X.25 links, a RAN data communication module (rDCM) **410** that provides an Internet Protocol (IP) interface, and an application service module **412** (ASM) that provides global title translation, gateway screening and other services. A translation service module (TSM) **414** may also be provided to support triggered local number portability

service. rDCM card **410** is a novel element of the present invention and is not describe any of the above-referenced publications regarding the IP7 secure gateway.

Additional modules that may be included in IP7 secure gateway **400** include SS7 link interface module (LIM) cards for sending and receiving SS7 messages over SS7 signaling links and data communication module (DCM) cards for sending and receiving IP encapsulated SS7 messages over an IP network, as described in the above referenced *Feature Notice IP^7 Secure Gateway™ Release 1.0* publication.

Figure 5 is a block diagram illustrating the internal architecture of RAN gateway **304** and the simplification of core network **302** according to an embodiment of the present invention. In the illustrated embodiment, RAN gateway includes MASP processors **500** for performing maintenance and administration functions, high speed link card **502** for sending and receiving messages over a high-speed ATM link, rDCM card **410** for translating between ATM and the core network protocol, and IMT bus **504** for providing communication between modules **500**, **410**, **500**, and **502**. RAN gateway **304** is connected to RNC **102** via an ATM network. Consequently, signaling messages received at by HSL module **502** within RAN gateway **304** will include a lower level ATM protocol component. RAN gateway **304** is also connected via an IP-based (e.g., SCTP/IP, TCP/IP, UDP/IP, etc.) communication link to a media gateway controller (MGC) **506** in core network **302**.

Each of the modules **410**, **500**, and **502** include hardware and software components for performing the functions described herein. For example,

each of the modules **410**, **500**, and **502** may include a printed circuit board with one or more microprocessors mounted thereon. In a preferred embodiment, each of the modules **410**, **500**, and **502** includes an application processor and a communication processor. The application processor of each module performs module-specific functions. For example, the application processor of rDCM **410** may perform SCTP/IP encapsulation of messages received from HSL module **502**. The communication processor of each module is responsible for sending and receiving messages via IMT bus **504**.

In operation, an ATM-based RAN signaling message sent by RNC **102** is received by HSL module **502** of RAN gateway **302**. In one embodiment, HSL module **502** may remove the lower level ATM protocol component of the message, and internally route the message to rDCM communication module **410**. HSL module **502** internally routes SS7 messages by examining the destination point code (DPC) in the message and converting the DPC into an internal card address.

rDCM module **410** may encapsulate some or all of an application part component of the message into a SUA, M3UA, TALI or equivalent wrapper. The TALI protocol is described in IETF Internet Draft <draft-benedyk-sigtran-tali-01.txt>, June 2000, the disclosure of which is incorporated herein by reference in its entirety. An SCTP/IP, TCP/IP, UDP/IP or equivalent IP-based protocol layer is then appended to the encapsulated message prior to transmission from rDCM **410**. The encapsulated IP message is then delivered via IP-based core network **302** to MGC node **506**.

Because RAN gateway translates incoming ATM messages to IP-based messages, core network **302** is greatly simplified. For example, core network **302** can include conventional IP-based elements, such as media gateway controllers, rather than ATM switches. In addition, because RAN gateway **304** includes ATM communication capabilities, modification to RNC nodes is not required.

Figure 6 is a network diagram illustrating two types of RAN signaling messages that may be encountered in a RAN network and consequently handled by a RAN gateway of the present invention. One type of RAN signaling message **600** contains a RAN application part (RANAP) component, a signaling connection control part (SCCP) component, a message transfer part level 3 broadband (MTP3B) component, and lower-level ATM-based components. Accordingly, RAN gateway **304** may be adapted to receive an ATM-based RAN message that contains such an application part structure, and subsequently encapsulate the application part components within an SUA wrapper. An SCTP/IP lower level is then appended to the SUA encapsulated RAN message, which is subsequently routed via IP-based core network **302** to a destination node. The resulting message is indicated by reference numeral **601** in Figure 6.

With regard to the SCCP component, RAN gateway **304** may or may not include this component in messages sent to IP-based core network **302**. For example, RAN gateway **304** may receive messages including RANAP, SCCP, MTP3B, and ATM components. In one embodiment, RAN gateway **304** may encapsulate the SCCP component in an SUA layer and send the SUA-encapsulated message to core network **302**. In such an embodiment,

the message send to core network **302** may include RANAP, SCCP, SUA, SCTP, and IP components. In an alternative embodiment, RAN gateway **304** may remove the SCCP layer from the message and replace the SCCP layer with an SUA layer. In such and embodiment the message sent to core network **302** may include RANAP, SUA, SCTP, and IP components. Either alternative is intended to be within the scope of the invention.

Another type of signaling message that may be encountered by RAN gateway **304** on the RNC side includes Q.2630.1 and Q.2150.1 application-level components lower-level SS7 and ATM-based components. Such a message is generally indicated by reference numeral **602**. RAN gateway **304** preferably removes the Q.2630.1 and Q.2150.1 layers and encapsulates these layers in an M3UA wrapper. RAN gateway **304** may then add an SCTP/IP lower-level component to form the message indicated by reference numeral **604**.

In addition to translating messages from the RNC side to the core network side, RAN gateway **304** may also translate messages received from the core network to a format recognizable by RNCs. For example, in Figure 6, RAN gateway **304** may receive a message **601** having a RANAP component, an SCCP component, an SUA component, and an SCTP/IP component. RAN gateway **304** may remove the upper-level RANAP and SCCP components, discard the lower-level SCTP/IP components, and add ATM components to form an ATM-based RANAP message **600**. Similarly, RAN gateway **304** may also receive messages from core network **302**, such as message **604**, that includes upper-level Q.2630.1 and Q.2150.1 components and lower-level SCTP/IP components. In response to these

messages, RAN gateway **304** may formulate a message with lower-level ATM components, as illustrated by reference numeral **602**. Thus, RAN gateway **304** is capable of translating messages received from the core network into a format recognizable by a radio network controller and vice versa.

Detailed Description of Processing of RANAP Messages

Figure 7 illustrates in detail the encapsulation and lower level protocol substitution functions for RANAP messages performed by RAN gateway **308** for RANAP messages. In Figure 7, protocol stack **200** represents the structure of a RANAP message received by RAN gateway **304** from an ATM-based radio network controller. Such a message includes a RANAP component, an SCCP component, an MTP3B component, an SSCF-NNI component, an SSCOP component, and an ATM component. RAN gateway **304** removes the RANAP and SCCP components from the message and encapsulates these components in an SUA wrapper. The SUA–encapsulated message is then itself encapsulated in an SCTP/IP wrapper. The transformed message is illustrated by protocol stack **700**. In protocol stack **700**, the transformed message includes a RANAP portion, an SCCP portion, an SUA portion, an SCTP portion, and an IP portion. All ATM components of the original message are removed. Accordingly, the need for ATM functionality in the core network is reduced.

When RAN gateway **304** receives a message formatted according to protocol stack **700**, RAN gateway **304** removes the RANAP and SCCP portions of the message and discards the lower-level SUA, SCTP, and IP portions. RAN gateway **304** then adds MTP3B, SSCF-NNI, SSCOP, AAL5,

and ATM components to the RANAP and SCCP components. The resulting message is formatted according to protocol stack **200**. This message can then be forwarded to an ATM-based RNC. Accordingly, because RAN gateway **304** is capable of formulating ATM-based RANAP messages based on SCT/IP-based RANAP messages, no modifications are required to existing radio network controller design.

Figure 8 is a detailed block diagram of rDCM module **410** of RAN gateway **304** according to an embodiment of the present invention. rDCM **410** is adapted to receive a RAN signaling message from an HSL communication module (shown in Figure 5) that is connected to internal IMT bus **800** of RAN gateway **304**. The RAN signaling message received by rDCM **410** has had lower level ATM protocol information removed, i.e., by HSL communication module **502** illustrated in Figure 5. The RAN signaling message is processed by a RAN gateway application layer **802** and routing instructions / information is obtained from a routing database **804** on rDCM **410**.

Detailed Explanation of RANAP and Q.2630.1 Message Routing for Messages Received From the RNC

Routing of a RANAP or Q.2630.1 message received from RNC **102** (illustrated in Figure 3) may occur as follows. HSL **502** (illustrated in Figure 5) receives the message, examines the DPC in the MTP3 part of the message and, if the message is destined for core network **104**, translates the DPC to the card address of rDCM **410**.

Translation of the DPC into the card address may include several intermediate steps. On HSL **502**, the DPC values in incoming messages are

used to determine linksets for the messages. Next, a linkset is chosen from the list of linksets available for the DPC, e.g., based on cost. Each linkset has a set of links to use for physical transmission. A link is directly associated with a card in the system, such as rDCM **410.** rDCM **410** has an SCTP association and stream that can carry SUA or M3UA traffic to core network **104**. Accordingly, the DPC in an incoming RANAP message may be translated as follows: DPC→linkset→link→card→SCTP association and stream.

An SCTP association is defined in the above-referenced RFC 2960 as a protocol relationship between SCTP endpoints. An association can be uniquely identified by the transport address used by endpoints in the association. A stream is defined as a uni-directional logical channel established from one to another associated endpoint through which all user messages are delivered in sequence except for those submitted to unordered delivery service.

According to the protocol, there can be only one association between SCTP endpoints. However, an endpoint is a logical entity, rather than a physical entity. rDCM **410** includes both hardware and software for communicating with core network elements. The software elements may include multiple processes for interfacing with the core network. Accordingly, rDCM **410** may have multiple SCTP associations with multiple core network elements.

Thus, an rDCM according to the present invention may establish an SCTP association with a core network element in order to communicate with an SCTP-based core network element. The steps for establishing such an

association are described in the above-referenced RFC and need not be described herein. If more than one message is required to be sent for a given transaction, the messages may be sent in an ordered stream to ensure in-order delivery. Alternatively, if the only a single SCTP message is being sent, or if in-order delivery is not of concern, rDCM may send the messages using unordered SCTP delivery service. Either method of using SCTP to communicate between a RAN gateway and the core network is intended to be within the scope of the invention. As an example, an incoming RANAP or Q.2630.1 message received from RNC **102** may have a destination point code of 2-2-2. DPC 2-2-2 may be associated with linksets Chicago A and Detroit B. In this example, Chicago A may be chosen based on the cost of the linkset. The linkset Chicago A may have one link, identified as 1201, which is assigned to card 1201. Card 1201 may be rDCM **410**. Accordingly, HSL **502** may send the message to rDCM **410** because rDCM **410** is located in slot 1201. rDCM **410** may then examine routing keys, such as destination point code (DPC) and service indicator (SI) in the message and match the DPC:SI with an SCTP association and send the message on the association.

Depending on the message type or information contained in the RAN signaling message, the message is passed to an appropriate encapsulation / application layer process **808A**, **808B**, or **808C**. In the example shown in Figure 8, the message is passed to SUA application process **808A**. SUA application process encapsulates the RANAP / SCCP / MTP3B content of the message within an SUA wrapper. The SUA wrapped packet is then directed to one of the appropriate SCTP/IP streams **808A-808N** for outbound transmission.

Detailed Description of Routing and Processing of RANAP Messages Received from the Core Network

RAN gateway **304** terminates the ATM, AAL5, SSCOP, SSCF-NNI, and MTP3B layers. The MTP3B layers include the MTP3 header and user part. rDCM **410** receives the message, discards the MTP3B part, and uses the user part to formulate the outgoing message. The user part may include, for example, the SCCP and RANAP portions of the message. The SCCP part is decoded to create the SUA part. The user part is then wrapped in SUA. SCTP and IP are then used to send to the IP-based node, such as a core network node.

The ATM part of the message is not important because each RNC has a point code and routing is performed based on point codes. HSL card **104** may have only one ATM virtual circuit, so there is only one path to send the message to the RNC.

As stated above, for SCTP/IP messages received fom core-network **104**, rDCM **410** of RAN gateway **304** may translate messages formatted according to protocol stack **700** into messages formatted according to protocol stack **200**. For example, referring to Figure 7, an incoming message from core network **104** may include a RANAP, SCCP, SUA, SCTP, and IP components. rDCM **410** of RAN gateway **304** removes the SCTP and IP layers from the message and discards these layers. Next, rDCM **410** examines destination information in the SUA layer to determine the final destination (point code) of the message. Based on the destination address in the SUA layer, the RANAP and SCCP parts of the original message are

placed in an SCCP message with a new routing label. The message is then forwarded to SS7 routing. SS7 routing examines the DPC in the new routing label. The DPC is then used to determine a card address as follows: DPC→link set→ link→ card, as discussed above. The message is then forwarded to the appropriate card via IMT bus **504**. If the destination is RNC **102**, the destination card may be HSL **502**. HSL **502** passes the message to MTP3B processing, which passes the message to MTP2 processing (ATM layer) for transmission. Thus, RAN gateway **304** is capable of converting non-ATM-formatted messages from core network **302** into an ATM format recognized by RNC **102**.

<u>Detailed Description of Processing of Q.2630.1 and Q.2150.1 Messages</u>

Figure 9 illustrates protocol stack translations performed by RAN gateway **304** for messages containing Q.2630.1 and Q.2150.1 components. Referring to Figure 9, protocol stack **202** represents the format of messages that may be received by RAN gateway from RNC nodes in order to set up bearer connections. In the illustrated example, such messages include a Q.2630.1 layer, a 2150.1 layer, an MTP3B layer, an SSCF-NNI layer, an AAL5 layer, and an ATM layer. RAN gateway **304** uses the Q.2150.1 layer to map messages between Q.2150.1 and M3UA. Exemplary Q.2150.1 and M3UA mappings are illustrated in Table 1 below.

Q.2150.1	M3UA
MTP PAUSE	DUNA
MTP RESUME	DAVA
MTP STATUS	SCON
MTP TRANSFER	DATA

Table 1: Q.2150.1—M3UA Mappings

Q.2150.1 is a two-sided interface. One side interfaces to MTP3B and is mapped according to Table 1. The other side is to Q.2630.1 which is not handled by M3UA. If core network **302** does not run a Q.2150.1 protocol stack, RAN gateway **304** may map the lower (MTP3B) side of the Q.2150.1 to a specific M3UA message, if such mapping is available, as indicated in Table 1. Alternatively, RAN gateway **304**, if core network **302** implements a Q.2150.1 protocol stack or if a specific mapping is not available, RAN gateway **304** may map everything from MTP3B up to an M3UA DATA message. Performing the mapping illustrated in Table 1 at RAN gateway **304** further simplifies core network elements.

A message is received by RAN gateway **304** from an RNC **102**. The message may include ATM, AAL5, SSCF-NNI, MTP3B, Q.2150.1, and Q.2630.1 components. HSL **502** processes the ATM, AAL5, SSCOP, and SSCF-NNI components in a manner that is dependent on conventional HSL design. The message is then passed to the MTP3B layer, which performs a mapping from DPC to linkset to link to card address as previously described. In this example, it is assumed that the card address is the address of rDCM **410**. The message is forwarded to rDCM **410** via IMT bus **504**.

Once the message arrives at rDCM **410**, the routing label is matched with an SCTP association and stream. At this point, rDCM **410** may examine the Q.2150.1 layer of the message and map the message type to an M3UA message type as illustrated above in Table 1. Alternatively, rDCM **410** may wrap the entire message into an M3UA DATA message without further examination of the Q.2150.1 layer. Thus, rDCM **410** may map Q.2150.1 messages to specific M3UA messages or convert all messages to Q.2150.1 data messages without examining the Q.2150.1 layer.

In addition to processing Q.2150.1 messages received on the RNC side, RAN gateway **304** is preferably also capable of processing such messages received from the core network. For example, RAN gateway **304** may receive a message from core network **302** that includes Q.2630.1, Q.2150.1, M3UA, SCTP, and IP-layers. The mapping of such messages into an ATM-based format may be similar to that described above for SUA messages. For example, when such a message is received by rDCM **410**, rDCM **410** examines the M3UA message type and converts the message to a standard SS7 MTP3B message using the DPC extracted from the M3UA layer. The message is then passed to SS7 routing where the message is routed as follows: DPC→linkset→link→card. In this example, it is assumed that the message is mapped to the card address for HSL card **502**. Accordingly, rDCM **410** routes the message to HSL card **502** via IMT bus **504**. The message is then sent over an outbound signaling link to RNC **102**.

In order to map incoming SUA and M3UA messages to standard SS7 messages, rDCM **410** may examine a protocol data parameter that corresponds to the SS7 routing label. RAN gateway **304** utilizes the protocol

data parameter to build the routing label. The routing label contains the standard SS7 destination point code which allows rDCM **410** to convert from DPC to card address. Thus, RAN gateway **304** is capable of converting and routing messages received from IP-based core network **302** to an RNC.

RAN Gateway with Billing System

Figures 10 and 11 illustrate embodiments of a RAN gateway that include a billing subsystem. As illustrated in Figure 11, rDCM **410** includes a billing process **1000** that is adapted to generate a billing message in response to the receipt of a RAN signaling message that satisfies a predetermined set of billing or message accounting criteria. RAN application layer **802** is adapted to pass billing process **1000** a copy of the received RAN signaling message, and billing process **1000** determines whether a billing message needs be generated. In the event that billing message generation is required, billing process **1000** creates a billing message and routes the billing message to a message accounting and billing subsystem **1100**, as indicated by the dashed line in Figure 11. In one embodiment, message accounting and billing subsystem **1100** may reside on an external processing platform that is communicatively coupled to RAN gateway **304** via a high speed Ethernet type connection. An ACM Ethernet controller **1102** is adapted to communicate with message accounting and billing subsystem **1100** located on external processing platform via the Ethernet link, and also with rDCM module **1000** via the internal IMT bus. Billing messages are received and processed by the message accounting and billing subsystem **1100**, and bills or invoices may be generated that indicate services provided, service recipients, and service

providers. For example, bills or invoices may be generated for access to a database, such as an HLR, owned by a service provider. If another service providers requires access to subscriber information in the database, the first service provider may bill the second service provider for the database access. Such billing may be based on RANAP messages and performed by the components illustrated in Figure 10 and 11.

In addition to generating bills and invoices, message accounting and billing subsystem **1100** may store messages and provide usage and measurements data for network monitoring or maintenance purposes. Finally, the present invention is not limited to a RAN gateway having an external message accounting and billing system. In an alternative embodiment, message accounting and billing system **1100** may be implemented on or by a printed circuit board internal to RAN gateway **304**.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation—the invention being defined by the claims.